EXHIBIT A
SCOPE OF SERVICES

DEDICATED SHORT RANGE COMMUNICATIONS BASED WARNING SYSTEM FOR WORKERS' SAFETY

BACKGROUND

In this project, the University will develop a Dedicated Short Range Communication (DSRC) based worker safety system which can provide the construction vehicle operators and passing by drivers more situational awareness about the other workers present in the vicinity. For the proposed system to work, it will be required to develop a small Global Positioning System (GPS) receiver with DSCR capability which each worker can wear on his or her arm, or it could be embedded in worker's jacket or helmet. The device's DSRC equipment will periodically transmit worker's GPS location which can be received by the DSRC device present in a nearby construction vehicle or a nearby DSRC equipped Programmable Changeable Message Signs (PCMSs). The construction vehicle's DSRC equipment will be interfaced with a monitor screen which will display the location of each worker present in the area to give a better awareness to the operator of the construction vehicle about the workers present in the vicinity. Similarly, the DSRC equipment present in PCMS will be able to auto-detect the presence of nearby workers on a particular section of the work zone, and warn the passing by drivers by displaying an appropriate sign. The proposed system could also improve the mobility of the work zone, especially if the work zone is a few miles long, by reducing the posted speed limit only on those sections of the work zone where workers are present and posting the normal speed limits around inactive sections of the work zone which do not have any workers present in the vicinity.

OBJECTIVE

Each year, over 20,000 workers are injured in United States work zones, and more than 100 workers die of such injuries. Most of these injuries occur due to accidents by construction vehicles (35%) or by accidents due to passing by traffic (12%) and almost all work zone deaths occur due to such accidents. If a construction vehicle operator could be given more situational awareness through a graphical display of the locations of the workers in the vicinity, then the construction vehicle operator could be more careful and many accidents and resulting injures could be avoided. This project seeks to achieve that goal via a DSRC based approach. This project relies on a small GPS receiver with DSRC capability to periodically transmit its GPS location via DSRC communication. These DSRC messages will be received by the DSRC devices installed in the construction vehicles, which could transport the worker's location to a visual monitor screen. This could give construction vehicle operators a better perception about presence of workers, thereby minimizing accidents.

In addition to helping minimize construction vehicle accidents, the proposed project will also help minimize passing-by traffic accidents involving workers by providing more realistic alerts to the drivers about workers' presence, using DSRC equipped PCMSs. Currently, on many work zones, static work zone signs are used to alert drivers about workers presence. If dynamic signs (e.g., PCMSs) are used, the display message needs to be changed manually. Although, it could be done remotely, manual input needs to be provided to PCMSs about workers presence or to post lower speed limits. This project will help alert the passing by drivers dynamically by having the DSRC equipped PCMSs auto-detect workers' locations and caution the drivers about their presence. This project could be especially useful if the work zones are longer, where some sections of the work zone may be inactive and others may have a concentration of workers. One of the goals of the project is to improve the mobility of the longer work zones by posting different speed limits on PCMSs located at various sections of the work zone. The DSRC equipped PCMSs could post lower speed limits if workers are detected in the vicinity and could post normal speed limits if a particular work zone section does not have a worker in the vicinity.

With the growing expectation that DSRC or connected vehicle technology will be used in future traffic safety and information systems; it is critical to explore this technology's use for construction worker's safety as well. This project will explore such feasibility, thereby advancing the connected vehicle technology mission of the United State Department of Transportation. This project will develop the hardware and software for DSRC-monitor interface, as well as a DSRC-PCMS interface using commercially available DSRC devices. This project will also explore the feasibility of developing a wearable DSRC device for workers, essential to practically implement the proposed DSRC based workers safety system.

SCOPE

A typical architecture of the proposed project is described in Figure 1, where a long work zone is shown with many workers, construction vehicles and passing by traffic. Each PCMS alongside the work zone will be equipped with a DSRC device through an interface as shown in Figure 2a. Similarly, each construction vehicle on the work zone will be equipped with a DSRC device connected to a monitor screen displaying the locations of the nearby workers graphically as shown in Figure 2b.

Each worker on the road will wear a DSRC device, which will periodically transmit its GPS location. Please note that the passing by vehicles on the open lane of the road are not required to have DSRC capability for the proposed worker safety system to work. However, if some of the vehicles are DSRC equipped, it will help increase the spacing between the two adjacent PCMSs, as will be explained later.

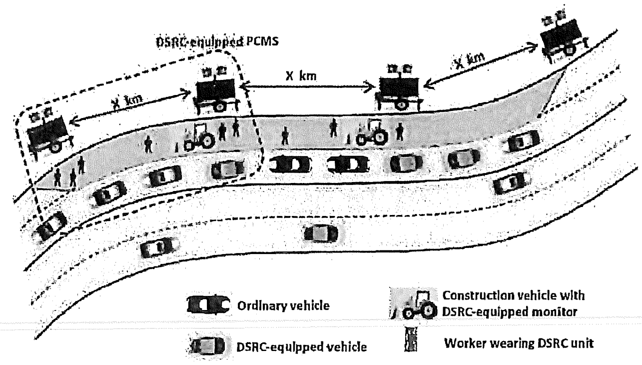

Figure 1: A typical architecture of the proposed project.

To achieve the intended goals of the proposed project, there are three critical aspects, which are explained in more detail below:

1. **Wearable GPS receiver with DSRC equipment for the workers:** The wearable GPS receiver having DSRC capability is the most crucial part of this project. The University will explore various design features and come up with the best design for such a device. The power requirement is the most important design consideration, so the device can be powered with a rechargeable battery that can last for at least one full work day. Although there are already some commercial GPS devices, commonly known as 'here I am' devices, available in the market, they transmit their location signals either using regular cellular technology or need to be interfaced with mobile phones if using DSRC technology. The University will explore the feasibility of a combination of GPS receiver and DSRC technology in one small box that does not rely on use of a mobile phone. In addition to the power requirement, the University will also look into the weight and size of the equipment so that it could be either worn as an arm band or could be retrofitted in the worker's jacket or helmet. The University will explore the best wearing configuration considering the line of sight (LoS) in DSRC technology to avoid any interruption in receiving the worker's location signal regardless of his or her orientation or work nature. Note, the University will explore the design feasibility of such a device in this project and use a regular boxed type DSRC device to demonstrate other aspects of the project. The University will work with a subcontractor, Savari Networks, to explore the possibility of development of such a device.

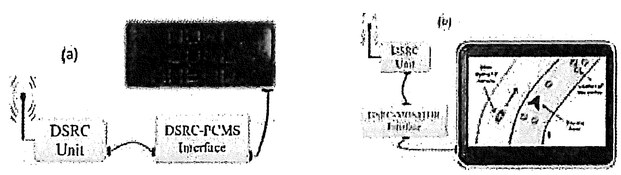

Figure 2: Conceptual architecture of (a) DSRC-PCMS interface, and (b) DSRC-Monitor interface.

2. **DSRC equipped construction vehicle with Monitor Screen:** The University will develop a DSRC-Monitor interface through which a construction vehicle operator can see the locations as graphical symbols to have a better awareness of workers' presence around the construction vehicle (Figure 2b). the University will also develop the needed mapping software for this purpose. The University will use an android or apple tablet as a monitor screen. The choice will be made based upon the consideration about which platform (android or iOS) will better allow external signals to seamlessly work with the operating system. The interface between the DSRC and the monitor screen will either be wireless (Wi-Fi or Bluetooth) or wired (serial or USB). The University will choose the best option and develop such an interface as part of the proposed project. Note, the University will not require internet for this interface to work, e.g., if the University chooses to do a Wi-Fi interface, it will be a device to device Wi-Fi without requiring internet in the work zone area. The University will also develop the necessary software for the monitor screen as well as develop programming needed for the DSRC device to work with both monitor screen and worker's wearable GPS receiver with DSRC capability.

3. **DSRC equipped PCMS**: The University previously developed a DSRC-PCMS interface, which they plan to use for workers safety and improve mobility of the work zone. The DSRC device installed at the PCMS will receive location signals from the nearby workers and will be able to post a speed limit depending upon workers' presence in the vicinity. In addition to the speed limit, PCMS could also warn the passing by drivers about the presence of workers on a particular section of the work zone. To achieve this goal, the University will determine what signs will be displayed by the PCMS and also what should be the optimal spacing between two adjacent PCMSs. The spacing will depend upon the direct wireless range of the DSRC technology as well as the percentage of the passing by vehicles with DSRC technology. If more DSRC equipped vehicles are present on the road, they could help hop the location signals emanating from workers' DSRC devices to PSMSs present in a farther location. The University will also develop a model to determine the optical spacing between PCMSs for a given DSRC market penetration rate. Please note that if none of the passing by vehicles are equipped with DSRC technology, the spacing between the two PCMSs will be determined by the direct access range of the DSRC technology in the order of half a km.

ASSISTANCE
The University will subcontract with Savari Networks, who will provide input on the feasibility of the development of a wearable GPS receiver with DSRC capability. Also, MnDOT's District 1 will provide some resources needed e.g., PCMSs.

WORK PLAN

Task Descriptions

Task 1: Feasibility of Wearable GPS Receiver with DSRC Capability
In this task, the University will explore the technical feasibility of a wearable device which has a GPS receiver as well as DSRC capability. The size, weight and antenna patterns will be explored to retrofit such a device on a worker's helmet, jacket, or to wear it as an armband. The University will also work with their subcontractor, Savari Networks, to explore the development of such a device in the future.

Task 2: Development and Demonstration of the DSRC-MONITOR Interface
In this task, the University will develop an interface through which a DSRC device can talk to a monitor screen (an android or iOS tablet). The University will prefer a wireless interface over a wired one because of the flexibility to use and develop such interface. The University will also develop communication protocol and programming for the DSRC device to communicate with the wearable DSRC devices of the workers.

Task 3: Development of the Mapping Software Needed for Monitor Screen
In this task, the University will develop the necessary mapping software for the monitor screen to graphically display the locations of nearby workers. The University will also demonstrate its working with the DSRC device through DSRC-MONITOR interface developed in task #2.

Task 4: Development and Demonstration of Software for DSRC equipped PCMSs
In this task, the University will develop the software for the DSRC device installed at PCMS to show the necessary information to the passing by drivers. Note, the University has already developed the DSRC-PCMS interface, so they will only develop the necessary software for DSRC devices installed at PCMS to receive the workers' location information and display appropriate signs and post desired speed limits. The task will be concluded with a field demonstration of working software.

Task 5: Compile Report, Technical Advisory Panel Review and Revisions
The University will prepare a draft report, following MnDOT's publication guidelines, to document project activities, findings and recommendations. This report will need to be reviewed by the Technical Advisory Panel (TAP), updated by the University's Principal Investigator, and then approved by the Technical Liaison before this task is considered complete. Holding a TAP meeting to discuss the draft report and review comments is strongly encouraged. TAP members may be consulted for clarification or discussion of comments.

Task 6: Final Published Report Completion
During this task, the Approved Report will be processed by MnDOT's Contract Editors. The editors will review the document to ensure the document meets the publication standard. The University's Principal Investigator will then prepare the Final Report and submit it for publication through MnDOT's publishing process.

Task Deliverables

Task:	Deliverable(s):
1:	Final Report, assessing the feasibility of development of a wearable GPS receiver with DSRC capability
2:	Design and Hardware, for the DSRC-MONITOR interface and DSRC device software
3:	A Tablet, with necessary mapping software and an interface to be connected with a DSRC device to graphically show nearby workers' locations
4:	Software for DSRC equipped PCMS to auto detect workers' presence and display corresponding safety alert and a variable speed limit
5:	A Draft Report and Final Report Approved for Publication
6:	Final Published Report

PROJECT SCHEDULE

Task Durations

	2014						2015												2016					
Months:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Task 1	X	X	X	X	X	X	X	X	X															
Task 2	X	X	X	X	X	X	X	X	X	X	X	X												
Task 3							X	X	X	X	X	X	X	X	X	X	X	X						
Task 4							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Task 5																		X	X	X	X	X		
Task 6																							X	X

Task Completion Dates

Task:	Completion Date:
1:	March 31, 2015
2:	June 30, 2015
3:	December 31, 2015
4:	April 30, 2016
5:	April 30, 2016
6:	June 30, 2016

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